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A New Permian Rugose Coral, *Wentzellophyllum pacificum*, from the Sakamotozawa Formation, Southern Kitakami Mountains, Northeast Japan

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Abstract The Sakamotozawa Formation exposed in Hikoroichi Town of Ofunato City, Iwate Prefecture, southern Kitakami Mountains is well-known to one of the standard lithogenetic units of the Lower Permian System in Japan. The formation consists mainly of well-bedded and dark colored limestone; it is subdivided into Sa to Sc members in which the detailed biostratigraphic subdivisions are established by a comprehensive account of fusulinaceans. The occurrence of rugose corals is rare but several characteristic species have been documented in this formation. During the recent quarry operation by the Ryushin Mining Co. Ltd., many large colonies of *Wentzellophyllum* are collected from limestone of the lower part of Sc member of the Sakamotozawa Formation. The corals are identified as a new species of *Wentzellophyllum*, *W. pacificum* that is described herein. This species probably represents one of the primitive forms in about 50 described species of this well-known genus.

Key words: Kitakami Mountains, Permian, Rugose coral, Sakamotozawa Formation, Waagenophyllidae, Wentzelellinae, *Wentzellophyllum*.

Introduction

The Sakamotozawa Formation is typically exposed in the Sakamotozawa Valley, Hikoroichi Town of Iwate Prefecture, southern Kitakami Mountains. The formation has long been studied by many authors and well-known to one of the standard lithogenetic units of the Lower Permian System in Japan. Among many reports of this formation, the detailed investigations by Mikami (1965) and Kanmera and Mikami (1965a, b) lead most comprehensive knowledge of the litho- and bio-stratigraphy of the Sakamotozawa. The formation consists dominantly of well-bedded and dark colored limestone that is divided into two (lower and upper) subformations. The lower subformation is further subdivided into four (Sa, Sb1 to Sb3) members, and two (Sc and Sd) members constitute the upper subformation. Furthermore, those authors subdivided the members into groups of beds based on the detailed observation of limestone microfacies and reconstructed the sedimentary environments. The age of the Sakamotozawa is enhanced by the abundant occurrence of fusulinaceans in limestone and assigned to Sakmarian to early Artinskian of the international Permian subdivisions.

Compared with the prolific occurrence of fusulinaceans in limestone of the Sakamotozawa, rugose corals are rare and the following three species have been described in the type area: *Lophophyllidium suetomii* Minato, *Durhamina kitakamiensis* Minato and Kato, and *Wentzelophyllum hayasakai* Minato and Kato (sic). Furthermore, the following species have been introduced from coeval limestones with the Sakamotozawa those are exposed in other areas of the southern Kitakami Mountains: *Yatsengia kabaya-*

maensis Minato, *Iranophyllum* (*Laophyllum*) *nakamurai* Minato and Kato, and *Pavastehphyllum* (*Sakamotozawanella*) *sakamotozawanum* Minato and Kato, *Polythecalis kitakamiensis* Minato and Kato, and some other unidentified species. Besides these rugose corals, a characteristic tabulate coral, *Michelinia* (*Michelinopora*) *multitabulata* Yabe and Hayasaka has been known to occur commonly in the upper part of the Sakamotozawa Formation.

The present rugose corals are collected from the western margin of quarry floor of the Taiheiyo Cement, Ofunato Mine, Sakamaotozawa Area shown in Fig. 1 (×) where well-bedded and dark gray limestone belonging to the lower part of Sc member is exposed. Many colonial coralla are scattered within the limestone and commonly attain 60 to 80 cm in diagonal; they are massive or tabular in overall shape. This coral is identified as a new species of *Wentzellophyllum*, *W. pacificum* Igo, Kamikawa and Igo that is described herein. The age of this coral is assigned

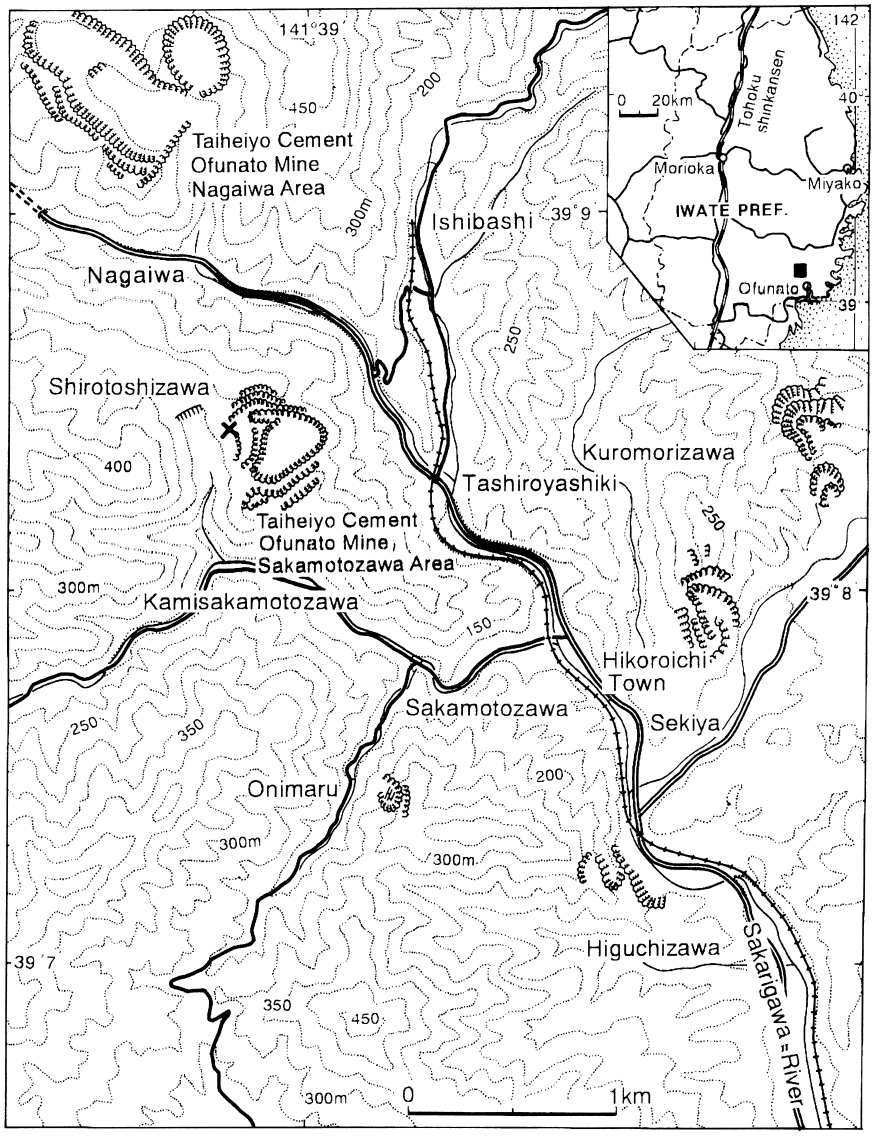


Fig. 1. Map showing locality of *Wentzellophyllum pacificum* Igo, Kamikawa and Igo, sp. nov. (×).

to early Artinskian (Yakhtashian) based on the joint occurrence of *Chalaroschwagerina vulgaris* (Schellwien) and other characteristic fusulinaceans (Kanmera & Mikami, 1965a, b).

Paleontological Note

The genus *Wenztellophyllum* was founded by Hudson (1958) with the type species of *Lonsdaleia volzi* Yabe and Hayasaka, 1915, which was originally described from the Chihsia Limestone of South China. Some of the subsequent authors (e.g., Minato & Kato, 1965; Hill, 1981; Lin *et al.*, 1995) spelled this genus name as *Wentzelophyllum*, but Hudson's original spelling, *Wentzellophyllum*, is apparently valid; hence the authors follow with the original. In the comprehensive study of the Waggenophyllidae by Minato and Kato (1965), these authors enumerated 18 species of *Wentzellophyllum*, which were mostly allocated to *Stylidophyllum* de Fromental, 1861. Besides the type species of this genus, *Wentzellophyllum* species are particularly abundant and wide-spread in the Chihsia Limestone and its coeval limestones of China. Among 49 described species of this genus, 38 species including two homonyms have been described in China. Chinese authors have established biostratigraphic zones of rugose corals in the lower part of the Chihsia Limestone based on the abundant occurrence of *Wentzellophyllum volzi* and other species. *Wentzellophyllum* species vigorously thrived in the shallow sea that extensively submerged the South China continental block in early Middle Permian time. This genus is rare in limestone exposed in the North China continental block, however, Yu *et al.* (1981) described *W. vesiculosum* from the Jilin district, Northeast China.

On the contrary, the occurrence of *Wentzellophyllum* is scarce in Japan. Among the synopsis of *Wentzellophyllum* species presented by Minato and Kato (1965), the following three species were known to occur in Japan: *W. eguchii* (Yokoyama, 1960), *W. hayasakai* Minato and Kato, 1965, and *W. kinkiense* (Sakaguchi and Yamagiwa, 1958). The description of the present new species is the fourth authenticated record of this genus in Japan, and the discovery of many large coralla in the limestone of the Sakamotozawa is worthy to note. The age of this new *Wentzellophyllum* that is constrained by the detailed fusulinacean biostratigraphy shows an earlier age than that of most previously known species. Furthermore, as will be described below, this species has a more primitive skeletal structure than that of many Chinese species.

The following synopsis is previously described *Wentzellophyllum* species, which are referred to propose the present new species by the authors.

1) *arctum* Wang, 1986; 2) *arminiae* (Felser, 1937); 3) *baijmense* Wang, 1978; 4) *chaoi* (Huang, 1932); 5) *crassum* Wang and Zhao, 1998; 6) *decorusum* Wang, 1978; 7) *denticulatum* (Huang, 1932); 8) *douglasi* Minato and Kato, 1965; 9) *eguchii* (Yokoyama, 1960); 10) *felseri* Minato and Kato, 1965; 11) *gelikhanense* Minato and Kato, 1965; 12) *hanshanense* Chen and Yan, 1982, in Nanjing Inst. Geol. Min. Res., 1982; 13) *hayasakai* Minato and Kato, 1965; 14) *huayunshanense* (Tseng, 1950); 15) *intermedium* (Huang, 1932); 16) *irregulare* Wang, 1978; 17) *irregulare* Wu and Zhao, 1982 (homonym), in Nanjing Inst. Geol. Min. Res., 1982; 18) *jenningsi* (Douglas, 1936); 19) *jianheense* Wang, 1978; 20) *kinkiense* (Sakaguchi and Yamagiwa, 1958); 21) *kueichowense* (Huang, 1932); 22) *langpotangense* Minato and Kato, 1965; 23) *longispinosum* Wang, 1986; 24) *magnicolumnare* Wang, 1986; 25) *megnicolumellum* Wang and Zhao, 1998; 26) *multitabellarum* Wang, 1978; 27) *orientale* (Douglas. 1936); 28) *permicum* (Douglas, 1936); 29) *proliferum* Zhao, 1981; 30) *rarispinum* Wang and Zhao, 1998; 31) *rariveiculatum* Wang, 1986; 32) *reticolumellum* Wang and Zhao, 1998; 33) *sertiseptatum* Zhao, 1981; 34) *shaozuoense* Wang, 1978; 35) *shuichengense* Wang, 1978; 36) *shuitangense* Wang, 1978; 37) *simplex* Wang, 1978; 38) *simplex* King, 1983 (homonym), in Xi'an Inst. Geol. Min. Res., 1983; 39) *subvolzi* Wu and Zhao, 1982, in Nanjing Inst. Geol. Min. Res.,1982; 40) *subsertisep-*

tatum Wu and Zhao, 1998; 41) *tabasense* Minato and Kato, 1965; 42) *verbeekielloides* King, 1983, in Xi'an Inst. Geol. Min. Res., 1983; 43) *vesiculosum* Yu, Lin and Huang, 1981; 44) *vesicitabulatum* Yan and Chen, 1982, in Nanjing Inst. Geol. Min. Res.,1982; 45) *volzi* (Yabe and Hayasaka, 1915); 46) *volzi jingxianense* Zhao and Chen, 1963; 47) *volzi tonglingense* Chen and Yan, 1982, in Nanjing. Inst. Geol. Min. Res., 1982; 48) *weiningense* Wang, 1978; 49) *yiwaense* King, 1983, in Xi'an Inst. Geol. Min. Res., 1983.

Recently, Lin *et al.* (1995) synonymized *Kepingophyllum* Wu and Zhou, 1982 with *Wentzellophyllum*. The genus *Kepingophyllum* was originally allocated in the family Wentzellophyllidae Yu, 1965 (Wu *et al.*, 1979), however, Wu and Zhou (1982) proposed the family Kepingophyllidae including the nominal genus and several other similar genera. Wu and Zhao (1984) noted that the first appearance of the genus is stratigraphically important; to settle the boundary between Carboniferous and Permian in China because *Kepingophyllum* species make their debut shortly after the first appearance of *Pseudoschwagerina* (Fusulinaceans) in the Maping Limestone (uppermost Carboniferous — lowermost Permian). *Kepingophyllum* is broadly similar to *Wentzellophyllum* in general corallite morphology, particularly in having the tertiary septa, variously developed transeptal dissepiments, and clinotabulae. As already emphasized by Wu and Zhao (1984), however, *Kepingophyllum* differs from *Wentzellophyllum* in having a brambly wall that permits both genera to be independent.

Description of Species

Family Waagenophyllidae Wang, 1950

Subfamily Wentzelellinae Hudson, 1958

Genus *Wentzellophyllum* Hudson, 1958

Type species: *Lonsdaleia volzi* Yabe and Hayasaka, 1915

Wentzellophyllum pacificum Igo, Kamikawa and Igo, sp. nov.

(Figs. 2–3)

Material. — Many large colonial coralla obtained. Three of them examined and from which five large oriented thin-sections and three polished slices prepared for identification.

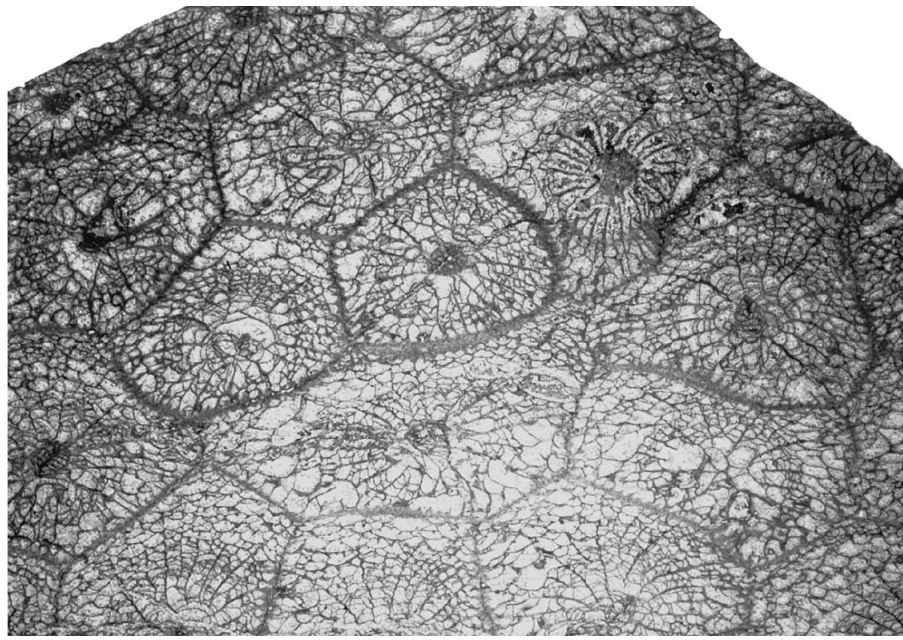
Depository. — Holotype (IGUT 8161), paratypes (IGUT 8162, 8163) housed in paleontological collections of Instituite of Geoscience, the University of Tsukuba.

Etymology. — Specific name *pacificum* denotes the Pacific Ocean; type locality of this new species is at a quarry floor of the Ofunato Mine, Sakamotozawa Area, Taiheiyo Cement Co. Ltd.; *Taiheiyo* literally means the Pacific Ocean in Japanese.

Diagnosis. — A *Wentzellophyllum* species with five- or six-sided, mostly cerioid corallites, about 8 to 14 mm across; straight or curved denticulated thin walls; about 10 to 15 major septa; rather long minor septa; short or denticulated tertiary septa; variable axial columns; variously developed transeptal dissepiments.

Description. — Corallum massive or tabular in overall shape, attains large in size, cerioid, aphroid in places.

Transverse section: Corallites rather small, polygonal with five- or six-sided, rounded corners in places; 8 to 14 mm (average about 11 mm) across at maturity. Wall thin for genus, consists of a thin translucent median layer and thicker denticulated outer layers; straight as well as curved, and partially vanished. Septa three orders, interrupted by various-sized transeptal (lonsdaleoid) dissepiments in places where these septa represented as septal crests or spines. Major septa thin, slightly dilated in tabularium; count 10 to 15 (average 12), straight or zigzag, long, but most of them are not directly continuous with elements of axial column. Counter septum rarely joints directly with median plate. Minor septa alternate with major septa; mostly 2/3 to 1/2 length of major ones. Tertiary septa are sporadic in immature corallites, well-developed



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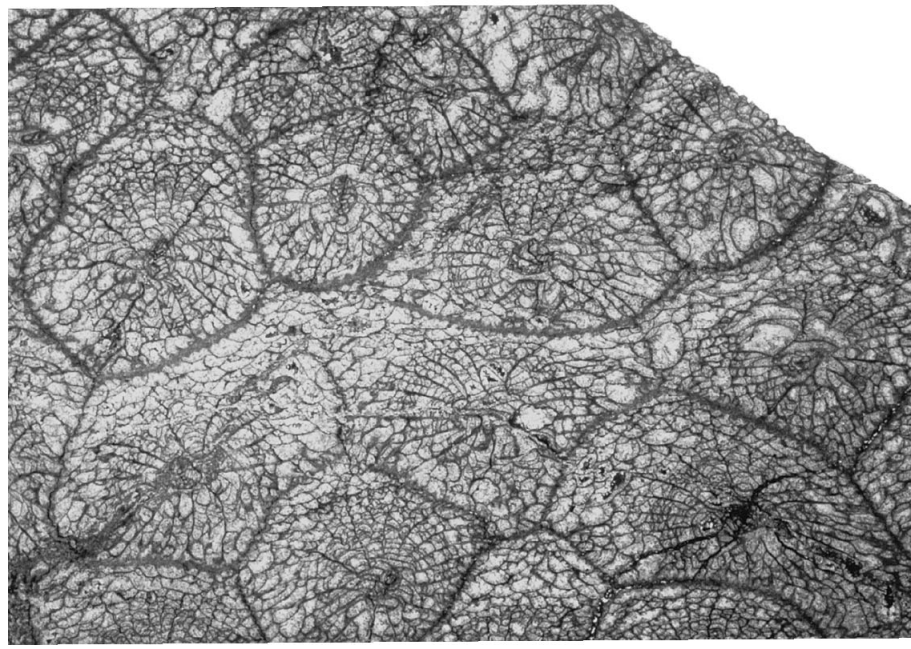

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Fig. 2. *Wentzellophyllum pacificum* Igo, Kamikawa and Igo, sp. nov. 1–2. Transverse sections of holotype (Reg. No. IGUT 8161), ×3.

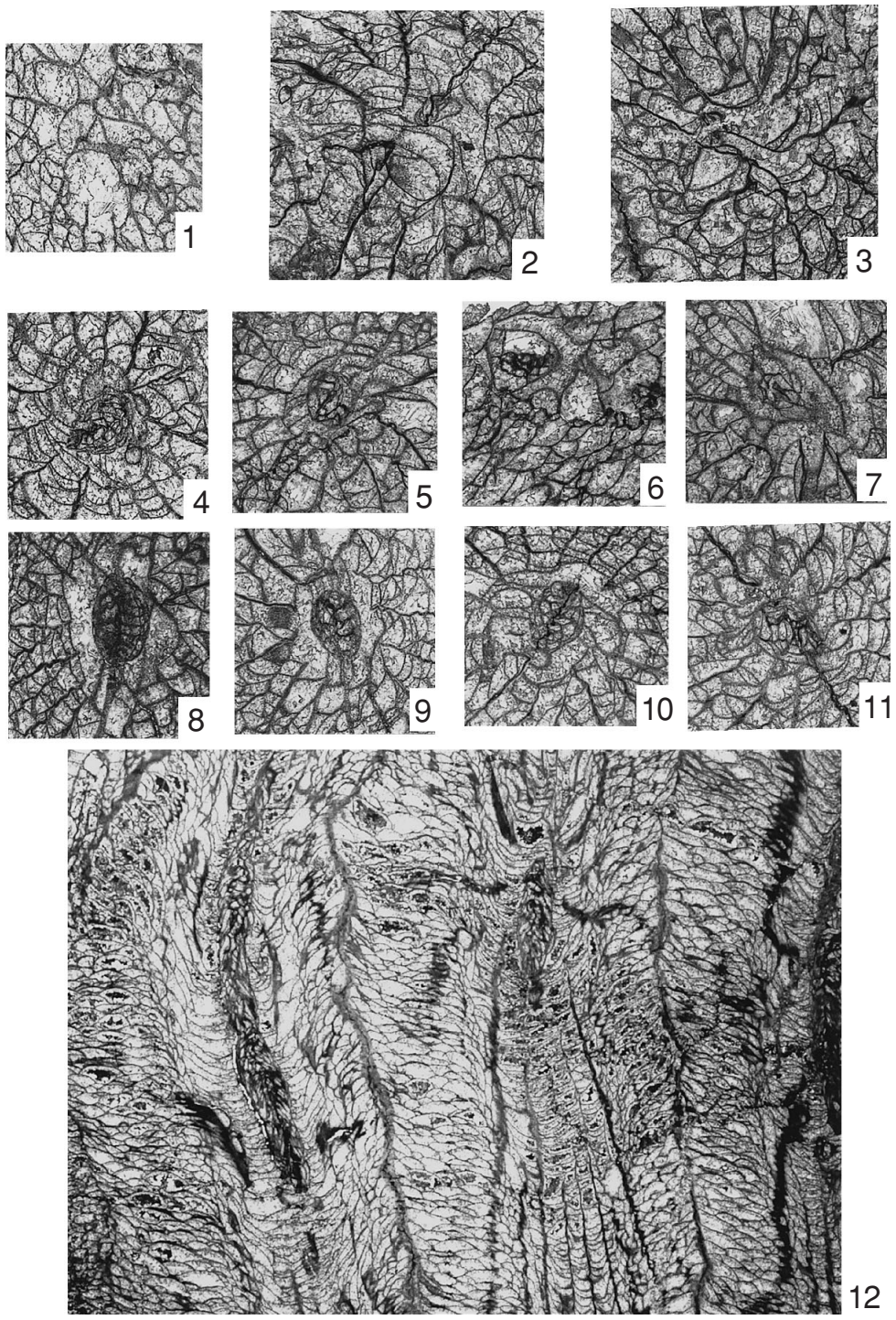

Fig. 3. *Wentzellophyllum pacificum* Igo, Kamikawa and Igo, sp. nov. 1–11. Transverse sections of middle portion of corallite showing variously constructed axial column, ×6. 12. longitudinal section of holotype (Reg. No. IGUT 8161), ×3.

in mature ones but mostly discontinuous; appear as septal spines or crests in cystose zone as well as denticles of wall.

Axial column commonly elliptical in outline, considerably variable in configuration, consists of a slightly thickened, straight or zigzag median plate, thin encircling intercepts of axial tabellae, several septal lamellae produced from median plate forming right angles. Axial structure becomes simple in corallites, which predate peripheral increase; such as loosely disposed intercepts of tabellae and/or a few lamellae prolonged from major septa.

Dissepimentarium occupies about 1/2 radius of corallite and consists of concentric and herrigbone interseptal dissepiments. Dissepiments more densely disposed in outer peripheral part. Transeptal dissepiments variously developed, occupy 3/5 to 4/5 of marginal areas in most mature corallite. In tabularium intercepts of tabulae are discernible in various degrees.

Longitudinal section: Corallites bounded by longitudinally undulating walls. Triaerial arrangement of axial column, tabularium, and dissepimentarium is distinct. Dissepimentarium is various in width, largely occupied with outer transeptal and inner globose dissepiments both of which commonly face upward; one to three ranks of elongate dissepiments are disposed in inner margin. Tabularium consists of clinotabulae, complete and incomplete inclined tabulae, which count 10 to 12 per vertical distance of 5 mm.

Axial column constructed by densely disposed conical axial tabellae, thin flexible median plate, and a few septal lamellae. This complicated column becomes structurally simple in corallites, which predate peripheral corallite increase.

Remarks. — The present new species differs from many other previously described species in smaller corallites which are circumscribed with curved thinner denticulated walls, fewer numbers of major septa, variously constructed axial columns, and less development of transeptal dissepiments. This skeletal feature can be explained as primitive specific characters in the genus.

Wentzellophyllum hayasakai Minato and Kato, 1965 described from the Sakamotozawa Formation exposed at the east of Sekiya is similar to this new species. The former, however, has slightly smaller corallites surrounded with thicker walls, more consistent axial columns, thicker major septa in tabularium, and more numbers of major septa.

Wentzellophyllum simplex Wang, 1978 reported from the Chihsia Limestone in Guizhou and Guangxi, Southwest China resembles the present Sakamotozawa species in broad corallite morphology, but this Chinese species has more consistent axial columns, more numbers of major septa, and better developed transpetal dissepiments. *W. crassum* Wang and Zhao, 1998 introduced also from China is somewhat similar to *W. pacificum*, but the former has a different axial structure, thicker and more numbers of major septa, and better developed transeptal dissepiments.

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